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MUTAGENICITY EVALUATION OF PICRAMIC ACID IN THE AMES SOLMONELLA--ETC(U)
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UNCLASSIFIED GENETICS ASSAY-3736 NL

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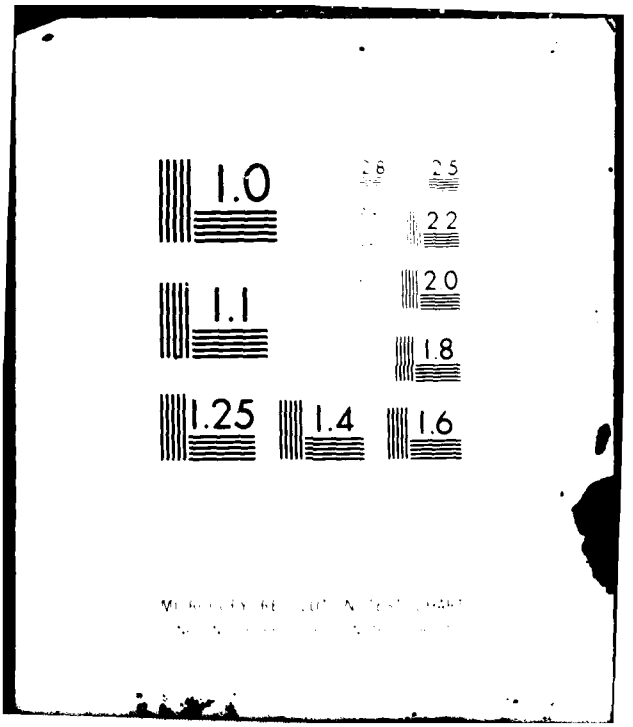
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Litton

BIONETICS

5516 Nicholson Lane
Kensington, Maryland
20795

GENETICS ASSAY # 3736

(1)

MUTAGENICITY EVALUATION OF

PICRAMIC ACID

IN THE AMES SALMONELLA/MICROSOME PLATE TEST

SEGMENT REPORT

N00014-78-C-0792

SUBMITTED TO:

DEPARTMENT OF THE NAVY
800 N. QUINCY STREET
ARLINGTON, VA. 22217

SUBMITTED BY:

LITTON BIONETICS, INC.
5516 NICHOLSON LANE
KENSINGTON, MARYLAND 20795

LBI PROJECT NO. 20988

FEBRUARY, 1979

Litton BIONETICS

I. SPONSOR: Department of the Navy

II. MATERIAL

A. Identification: Picramic Acid

B. Date Received: November 7, 1978

C. Physical Description: Brown powder

III. TYPE OF ASSAY: Ames Salmonella/Microsome Plate Test

IV. PROTOCOL NO.: DMT-100

V. RESULTS

The results of the assay are presented in Table 1.

VI. INTERPRETATION OF RESULTS AND CONCLUSIONS

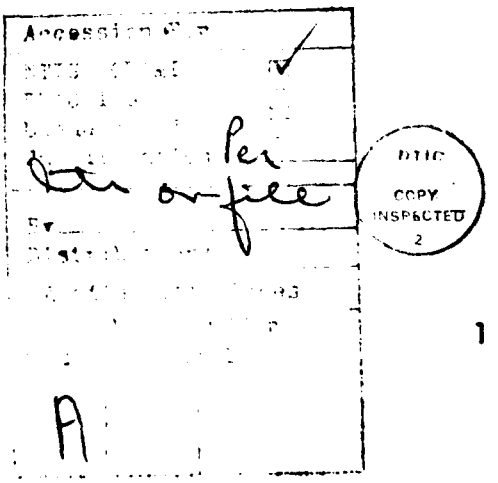
The test compound was examined for mutagenic activity in a series of in vitro microbial assays employing Salmonella and Saccharomyces indicator organisms. The compound was tested directly and in the presence of liver microsomal enzyme preparations from Aroclor-induced rats.

The compound was tested over a series of concentrations such that there was either quantitative or qualitative evidence of some chemically-induced physiological effects at the high dose level. The low dose in all cases was below a concentration that demonstrated any toxic effect. The dose range employed for the evaluation of this compound was from 0.5 µg to 1000 µg per plate.

The results of the tests conducted on the compound in the absence of a metabolic system were positive with all the Salmonella strains.

The results of the tests conducted on the compound in the presence of the rat liver activation system were positive with all the Salmonella strains.

The test with TA-1538 was repeated because of contamination in the initial nonactivation and activation assays.



VI. INTERPRETATION OF RESULTS AND CONCLUSIONS (Continued)

The test compound Picramic Acid exhibited genetic activity with all the Salmonella strains in the activation and nonactivation assays conducted in this evaluation and is considered as mutagenic under these test conditions. These tests indicate that the test compound does not require metabolic activation to cause genetic activity and that the parent compound in itself is mutagenic.

Submitted by:

Study Director

D.R. Jagannath 2.14.79

D.R. Jagannath, Ph.D. Date
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Reviewed by:

David J. Brusick 2/14/79

David J. Brusick, Ph.D. Date
Director
Department of Genetics
and Cell Biology

V. RESULTS

TABLE 1

a. NAME OR CODE DESIGNATION OF THE TEST COMPOUND: PICRAMIC ACID
b. SOLVENT: DIST WATER
c. TEST INITIATION DATE: 01/23/79
NOTE: CONCENTRATIONS ARE GIVEN IN MICROLITERS (UL) OR MICROGRAMS (UG) PER PLATE.

TEST	SPECIES	TISSUE	REVERTANTS PER PLATE TA-1535 1	TA-1535 2	TA-1537 1	TA-1537 2	TA-1538 1	TA-1538 2	TA-98 1	TA-98 2	TA-100 1	TA-100 2	D4* 1	D4* 2
NONACTIVATION														
SOLVENT CONTROL	---	---	22		22		C	18	26		199		104	
POSITIVE CONTROL**	---	---	1157		611		C	992	1205		1367		502	
TEST COMPOUND														
0.500000 UG	---	---	26		27		C	16	11		165		92	
1.000000 UG	---	---	17		21		C	12	17		173		96	
10.000000 UG	---	---	21		56		C	21	17		267		95	
100.000000 UG	---	---	69		255		C	139	99		1015		74	
500.000000 UG	---	---	70		806		C	283	250		1550		101	
1000.000000 UG	---	---	109		509		C	395	337		1558		102	
ACTIVATION														
SOLVENT CONTROL	RAT	LIVER	21		23		C	15	37		197		105	
POSITIVE CONTROL***	RAT	LIVER	521		112		C	1920	2146		1749		118+	
TEST COMPOUND														
0.500000 UG	RAT	LIVER	27		22		C	20	28		147		136	
1.000000 UG	RAT	LIVER	15		33		C	18	22		168		124	
10.000000 UG	RAT	LIVER	28		73		C	25	49		246		88	
100.000000 UG	RAT	LIVER	78		414		C	73	107		623		117	
500.000000 UG	RAT	LIVER	104		892		C	174	192		1233		125	
1000.000000 UG	RAT	LIVER	87		756		C	293	308		1155		125	

* TRY+ REVERTANTS PER PLATE

** TA-1535 SODIUM AZIDE 1 UG/PLATE
TA-1537 9-AMINOACRIDINE 50 UG/PLATE
TA-1538 2-NITROFLUORENE 10 UG/PLATE
TA-98 2-NITROFLUORENE 10 UG/PLATE
TA-100 SODIUM AZIDE 1 UG/PLATE
D4 N-METHYL-N-NITRO-N-NITROSOGUANIDINE 10 UG/PLATE
SOLVENT 50 UL/PLATE

*** TA-1535 2-ANTHRAMINE 2.5 UG/PLATE
TA-1537 2-ANTHRAMINE 2.5 UG/PLATE
TA-1538 2-ANTHRAMINE 2.5 UG/PLATE
TA-98 2-ANTHRAMINE 2.5 UG/PLATE
TA-100 2-ANTHRAMINE 2.5 UG/PLATE
D4 2-ANTHRAMINE 2.5 UG/PLATE

+ THERE IS NO KNOWN POSITIVE CONTROL COMPOUND THAT WORKS CONSISTENTLY WITH THIS STRAIN IN THE ACTIVATION PLATE ASSAYS.

C= CONTAMINATION

PROTOCOL

1. PURPOSE

The purpose of this study was to evaluate the test material for genetic activity in a microbial assay with and without the addition of mammalian metabolic activation preparations.

2. MATERIALS

A. Indicator Microorganisms

Salmonella typhimurium	TA-1535 TA-1537 TA-1538 TA-98 TA-100
Saccharomyces cerevisiae	D4

B. Activation System

1. Reaction Mixture

Component	Final Concentration/ml
TPN (Sodium salt)	4 µmol
Glucose-6-phosphate	5 µmol
Sodium phosphate (dibasic)	100 µmol
$MgCl_2$	8 µmol
KCl	33 µmol
Homogenate S9 fraction	0.1 ± 0.05 ml

2. S9 Homogenate

A 9,000 x g supernatant prepared from Sprague-Dawley adult male rat liver induced by Aroclor 1254 lot #BIO-82 was purchased from Biological Products, Litton Bionetics, Inc. and was used in these assays.

2. MATERIALS (Continued)

C. Positive Control Chemicals

The chemicals used for positive controls in the nonactivation and activation assays are given in Table 1 of Section V. Results.

D. Solvent

The solvent employed to prepare the stock solution of the test chemical is given in Table 1 of Section V. Results.
All dilutions of the test chemical were made using this solvent.

3. EXPERIMENTAL DESIGN

A. Plate Test (Agar Incorporation)

Approximately 10^8 cells from an overnight culture of each indicator strain were added to separate test tubes containing 2.0 ml molten agar supplemented with biotin and a trace of histidine. For non-activation tests, at least 4 dose levels of the test compound were added to the contents of the appropriate tubes and poured over the surfaces of selective agar plates. In activation tests, at least 4 dose levels of the test chemical were added to the appropriate tubes with cells. Just prior to pouring, an aliquot of reaction mixture (0.5 ml containing the 9,000 x g liver homogenate) was added to each of the activation overlay tubes, which were then mixed, and the contents poured over the surface of a minimal agar plate and allowed to solidify. The plates were incubated for 48 hrs at 37°C and scored for the number of colonies growing on each plate. D4 yeast plates were incubated at 30°C for 3-5 days and then scored. The concentrations of all chemicals are given in Table 1 of Section V. Results. Positive and solvent controls using both directly active positive chemicals and those that require metabolic activation were run with each assay.

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* Certain classes of chemicals known to be mutagens and carcinogens do not produce detectable responses using the standard Ames agar incorporation method. Some dialkyl nitrosamines and certain substituted hydrazines are mutagenic in suspension assays, but not in the plate assay. Chemicals of these classes should be screened in a suspension assay.

3. EXPERIMENTAL DESIGN (Continued)

B. Recording and Presenting Data

The numbers of colonies on each plate were counted and recorded on printed forms. These raw data were analyzed in a computer program and reported on a printout. The results are presented as revertants (or convertants for D4) per plate for each indicator strain employed in the assay. The positive and solvent controls are provided as reference points. Other relevant data are provided on the computer printout.

4. EVALUATION CRITERIA

Plate test data consist of direct revertant colony counts obtained from a set of selective agar plates seeded with populations of mutant cells suspended in a semisolid overlay. Because the test chemical and the cells are incubated in the overlay for 2 days, and a few cell divisions occur during the incubation period, the test is semiquantitative in nature. Although these features of the assay reduce the quantitation of results, they provide certain advantages not contained in a quantitative suspension test:

- The small number of cell divisions permits potential mutagens to act on replicating DNA, which is often more sensitive than nonreplicating DNA.
- The combined incubation of the compound and the cells in the overlay permits constant exposure of the indicator cells for 2 days.

A. Surviving Populations

Plate test procedures do not permit exact quantitation of the number of cells surviving chemical treatment. At low concentrations of the test chemical, the surviving population on the treatment plates is essentially the same as that on the negative control plates. At high concentrations, the surviving population is usually reduced by some fraction. Our protocol normally employs several doses ranging over 2 or 3 log concentrations, the highest of these doses being selected to show slight toxicity as determined by subjective criteria.

B. Dose Response Phenomena

The demonstration of dose-related increases in mutant counts is an important criterion in establishing mutagenicity. A factor that might modify dose-response results for a mutagen would be the selection of doses that are too low (usually mutagenicity and toxicity are related). If the highest dose is far lower than a toxic concentration, no increases may be observed over the dose range selected.

4. EVALUATION CRITERIA (Continued)

B. Dose-Response Phenomena

Conversely, if the lowest dose employed is highly cytotoxic, the test chemical may kill any mutants that are induced, and the compound will not appear to be mutagenic.

C. Control Tests

Positive and negative control assays are conducted with each experiment and consist of direct-acting mutagens for nonactivation assays and mutagens that require metabolic biotransformation in activation assays. Negative controls consist of the test compound solvent in the overlay agar together with the other essential components. The negative control plate for each strain gives a reference point to which the test data are compared. The positive control assay is conducted to demonstrate that the test systems are functional with known mutagens.

D. Evaluation Criteria for Ames Assay

Because the procedures used to evaluate the mutagenicity of the test chemical are semiquantitative, the criteria used to determine positive effects are inherently subjective and are based primarily on a historical data base. Most data sets are evaluated using the following criteria:

1. Strains TA-1535, TA-1537 and TA-1538

If the solvent control value is within the normal range, a chemical that produces a positive dose response over three concentrations with the lowest increase equal to twice the solvent control value is considered to be mutagenic.

2. Strains TA-98, TA-100 and D4

If the solvent control value is within the normal range, a chemical that produces a positive dose response over three concentrations with the highest increase equal to twice the solvent control value for TA-100 and 2-3 times the solvent control value for strains TA-98 and D4 is considered to be mutagenic. For these strains, the dose-response increase should start at approximately the solvent control value.

4. EVALUATION CRITERIA (Continued)

D. Evaluation Criteria for Ames Assay

3. Pattern

Because TA-1535 and TA-100 are both derived from the same parental strain (G-46) and because TA-1538 and TA-98 are both derived from the same parental strain (D3052), there is a built-in redundancy in the microbial assay. In general, the two strains of a set respond to the same mutagen and such a pattern is sought. It is also anticipated that if a given strain, e.g., TA-1537, responds to a mutagen in nonactivation tests, it will generally do so in activation tests (the converse of this relationship is not expected). While similar response patterns are not required for all mutagens, they can be used to enhance the reliability of an evaluation decision.

4. Reproducibility

If a chemical produces a response in a single test that cannot be reproduced in one or more additional runs, the initial positive test data lose significance.

The preceding criteria are not absolute, and other extenuating factors may enter into a final evaluation decision. However, these criteria are applied to the majority of situations and are presented to aid those individuals not familiar with this procedure. As the data base is increased, the criteria for evaluation can be more firmly established.

E. Relationship Between Mutagenicity and Carcinogenicity

It must be emphasized that the Ames Salmonella/Microsome Plate Test is not a definitive test for chemical carcinogens. It is recognized, however, that correlative and functional relationships have been demonstrated between these two endpoints. The results of comparative tests on 300 chemicals by McCann et al. (1975) show an extremely good correlation between results of microbial mutagenesis tests and in vivo rodent carcinogenesis assays.

All evaluations and interpretation of the data presented in this report are based only on the demonstration, or lack, of mutagenic activity.

REFERENCES

Ames, B.N., McCann, J. and Yamasake, E. (1975). Methods for detecting carcinogens and mutagens with the Salmonella/ mammalian-microsome mutagenicity test. Mutation Res. 31, 347-364.

McCann, J., Choi, E., Yamasaki, E. and Ames, B.N. (1975). Detection of carcinogens as mutagens in the Salmonella/microsome test: Assay of 300 chemicals. Proc. Nat. Acad. Sci. 72, 5135-5139.

LBI ASSAY NO. 3736

LBI SAFETY NO. 3303

MUTAGENICITY EVALUATION OF

PICRAMIC ACID

IN THE MOUSE LYMPHOMA FORWARD MUTATION ASSAY

SEGMENT REPORT

SUBMITTED TO:

DEPARTMENT OF THE NAVY
800 N. QUINCY STREET
ARLINGTON, VA. 22217

SUBMITTED BY:

LITTON BIONETICS, INC.
5516 NICHOLSON LANE
KENSINGTON, MARYLAND 20795

LBI PROJECT NO. 20989

REPORT DATE: APRIL 1979

Litton BIONETICS

PREFACE

This report contains a summary of the data compiled during the evaluation of the test compound. The report is organized to present the results in a concise and easily interpretable manner. The first part contains items I-IX. Items I-IV provide sponsor and compound identification information, type of assay, and the protocol reference number. All protocol references indicate a standard procedure described in the Litton Bionetics, Inc. "Screening Program for the Identification of Potential Mutagens and Carcinogens." Item V provides the initiation and completion dates for the study, and Item VI provides identification of supervisory personnel. Item VII identifies the tables and/or figures containing the data used by the study director in interpreting the test results. The interpretation itself is in Item VIII. Item IX provides the conclusion and evaluation.

The second part of the report, entitled PROTOCOL, describes the materials and procedures employed in conducting the assay. This part of the report also contains evaluation criteria used by the study director, and any appendices. The evaluation criteria are included to acquaint the sponsor with the methods used to develop and analyze the test results.

All test and control results presented in this report are supported by fully documented raw data which are permanently maintained in the files of the Department of Genetics and Cell Biology or in the archives of Litton Bionetics, Inc., 5516 Nicholson Lane, Kensington Maryland, 20795.

Copies of raw data will be supplied to the sponsor upon request.

I. SPONSOR: Department of the Navy

II. MATERIAL (TEST COMPOUND): LBI ASSAY NUMBER 3736

A. Identification: Picramic Acid

B. Date Received: November 7, 1978

C. Physical Description: Brown Powder

III. TYPE OF ASSAY: Mouse Lymphoma Forward Mutation Assay

IV. PROTOCOL NUMBER: 431 (DMT-106)

V. STUDY DATES:

A. Initiation: November 30, 1978

B. Completion: February 25, 1979

VI. SUPERVISORY PERSONNEL:

A. Study Director: Brian Myhr, Ph.D.

B. Laboratory Supervisor: Marie McKeon

VII. RESULTS:

The data are presented in Tables 1 and 2 on pages 4 and 5.

VIII. INTERPRETATION OF RESULTS:

The test material, picramic acid, was insoluble in water at high concentration and was dissolved in DMSO at 500 mg/ml for the preliminary cytotoxicity test. Dilutions were performed with DMSO prior to final 1:100 dilutions into growth medium to obtain an applied concentration range of 5000 µg/ml to 10 µg/ml. The test material appeared to remain soluble in the growth medium, although the color became progressively more brown with higher concentrations. Twenty-four hours after treatment, the cell count was highly reduced in the culture exposed to 156 µg/ml, and concentrations of 313 µg/ml and higher were completely lethal. Therefore, the mutation assay was initiated with a series of concentrations in the 300 µg/ml to 15 µg/ml range.

Two trials of the mutation assay were initiated and the results are presented in Tables 1 and 2.

INTERPRETATION OF RESULTS:

Under nonactivation conditions, five treatments causing high to very high toxicity were analyzed for mutagenic activity (Table 1). The frequencies of mutants in the treated cultures ranged from 1.7 to 2.2 times the background frequency (average of the solvent and untreated negative control values) for the 100 µg/ml to 240 µg/ml concentration range. These treatments resulted in percent relative growth values that ranged from 12.4% to 5.2%. Since a 2.5-fold increase is considered the minimum criterion for demonstrating mutagenic activity, these results did not provide good evidence for any mutagenicity. In fact, assays which extend to treatments causing about 5% to 10% relative growth without inducing mutant frequencies greater than 2.5 times the background are normally considered sufficient to demonstrate the lack of mutagenic action. In this trial, however, an additional treatment (300 µg/ml), highly toxic to the cells (1.8% relative growth), was included and the mutant frequency increased to about 4.4 times the background. This value should be regarded with some caution because the relative cloning efficiency dropped suddenly to only 45.0%. If the actual relative cloning efficiency had been near the other values (about 90%), the calculated mutant frequency would have been about 2.2 times the background and not regarded as significantly different from the background.

A repeat nonactivation assay was performed (Table 2) in an attempt to confirm any mutagenic activity at very high toxicity. However, in this trial, 240 µg/ml and 300 µg/ml were too toxic to complete the assay, and treatments with 30 µg/ml to 200 µg/ml yielded percent relative growth values from 38.6% to 11.3%. The mutant frequencies in all the treated cultures were comparable to the background. Therefore, the test material was considered to be inactive as a mutagen over the usual toxicity range of the assay, but some mutagenic activity may be associated with very highly toxic treatments (relative growth of 2% or less).

In the presence of the S9 microsomal activation mix, the test material became somewhat more toxic, indicating a reaction with the activating system. Applied concentrations from 60 µg/ml to 150 µg/ml were assayed in the first trial (Table 1); the next highest applied concentration of 200 µg/ml was completely lethal. The mutant frequencies remained less than 2.5 times the background for treatments that reduced the percent relative growth to as low as 10.9%. The very toxic treatment with 150 µg/ml (4.0% relative growth) resulted in a 2.9-fold increase in mutant frequency. However, the relative cloning efficiency also dropped to 43.5%, so the increase in mutant frequency might be apparent and not repeatable. The second assay (Table 2) did not resolve

INTERPRETATION OF RESULTS:

this question, since the test material was less toxic over the same concentration range (but still lethal at 200 µg/ml). At 150 µg/ml, the percent relative growth was 19.3% and the mutant frequency was only about 2 times the background. The mutant frequencies in the other treated cultures were even less. Thus, the test material was not demonstrably mutagenic for treatments in the normal toxicity range of the assay, but highly toxic treatments (relative growth below 10%) may be weakly mutagenic.

The validity of the mutation assays can be assessed by the results obtained for the positive and negative controls. The average cloning efficiencies for the solvent and untreated negative controls varied from 62% (Table 1) to 85% (Table 2) without activation and from 86% (Table 1) to 95% (Table 2) with activation, which demonstrated excellent culturing conditions for the assays. The negative control mutant frequencies were all in the normal range, and the positive control compounds yielded mutant frequencies in the normal range that were greatly in excess of the background.

CONCLUSIONS:

The test material, picramic acid, was not demonstrably mutagenic at the TK locus in L5178Y mouse lymphoma cells at concentrations causing moderate to high toxicity (30 µg/ml to 240 µg/ml without activation and 15 µg/ml to 150 µg/ml with microsomal activation). Some evidence was obtained, however, for weak mutagenic activity for extremely toxic treatments causing less than about 2-4% relative growth under both activation and nonactivation conditions.

Therefore, the test material is considered to be inactive in the Mouse Lymphoma Forward Mutation Assay.

Submitted by:
Study Director

Brian C. Myhr 4/10/79

Brian Myhr, Ph.D. date
Section Chief
Mammalian Genetics
Department of Genetics
and Cell Biology

Reviewed by:

David J. Brusick 4/10/79

David J. Brusick, Ph.D. date
Director
Department of Genetics
and Cell Biology

4. SUMMARY OF MOUSE LYMPHOMA (L5178Y) RESULTS

TABLE 1

A. NAME OR CODE DESIGNATION OF THE TEST COMPOUND: PICRAMIC ACID
B. LBI CODE #: 3736
C. SOLVENT: DIMETHYL SULFOXIDE
D. TEST DATE: 01/03/79

TEST	S-9 SOURCE	S-9 TISSUE	DAILY COUNTS (CELLS/ML X 10E5) 1	2	3	RELATIVE SUSPENSION GROWTH (% OF CONTROL)	TOTAL MUTANT CLONES	TOTAL VIABLE CLONES	RELATIVE CLONING EFFICIENCY (% OF CONTROL)	PERCENT RELATIVE GROWTH*	MUTANT FREQUENCY** (X 10E-6)
NONACTIVATION											
SOLVENT CONTROL	---	---	15.4	11.0		100.0	25.0	196.0	100.0	100.0	12.8
SOLVENT CONTROL	---	---	17.4	13.0		100.0	12.0	163.0	100.0	100.0	7.4
UNTREATED CONTROL	---	---	13.8	11.2		78.1	36.0	195.0	108.6	84.9	18.5
EMS .5 UL/ML	---	---	9.0	4.8		21.8	359.0	69.0	38.4	8.4	520.3
TEST COMPOUND											
100.000 UG/ML	---	---	4.4	7.2		16.0	39.0	139.0	77.4	12.4	28.1
150.000 UG/ML	---	---	5.4	4.8		13.1	37.0	168.0	93.6	12.3	22.0
200.000 UG/ML	---	---	3.2	3.8 ++		5.8	44.0	202.0	88.8	5.2	21.8
240.000 UG/ML	---	---	2.6	4.8		7.3	50.0	231.0	128.7	9.4	21.6
300.000 UG/ML	---	---	0.6	2.6 ++		3.9	40.0	70.0	45.0	1.8	57.1
ACTIVATION											
SOLVENT CONTROL	RAT	LIVER	17.0	6.8		100.0	58.0	295.0	100.0	100.0	19.7
SOLVENT CONTROL	RAT	LIVER	13.0	9.2		100.0	81.0+	253.0	100.0	100.0	32.0
UNTREATED CONTROL	RAT	LIVER	11.2	13.8		131.4	81.0	223.0	81.4	107.0	36.3
DMN .3 UL/ML	RAT	LIVER	8.4	4.6		32.9	146.0	43.0	15.7	5.2	339.5
TEST COMPOUND											
60.000 UG/ML	RAT	LIVER	8.2	7.4		51.6	96.0	243.0	88.7	45.8	39.5
75.000 UG/ML	RAT	LIVER	5.0	4.8		20.4	53.0	333.0	121.5	24.8	15.9
100.000 UG/ML	RAT	LIVER	7.4	5.8		36.5	100.0	175.0	63.9	23.3	57.1
120.000 UG/ML	RAT	LIVER	3.4	6.2		15.8	114.0	189.0	69.0	10.9	60.3
150.000 UG/ML	RAT	LIVER	0.8	3.6 ++		9.2	123.0	143.0	43.5	4.0	86.0

* (RELATIVE SUSPENSION GROWTH X RELATIVE CLONING EFFICIENCY) / 100 .

** THE RATIO OF CELLS SEEDED FOR MUTANT SELECTION TO CELLS SEEDED FOR CLONING EFFICIENCY IS 10E+4. THEREFORE THE MUTANT FREQUENCY IS: (TOTAL MUTANT CLONES/TOTAL VIABLE CLONES)*10E-4. THE MUTANT FREQUENCY IS GIVEN IN UNITS OF 10L-6.

\+ = ONE PLATE CONTAMINATED; VALUE BASED ON REMAINING TWO PLATES.

++ = DUE TO TOXICITY, EITHER THE CULTURE WAS NOT SPLIT BACK TO 3.0 x 10^6 CELLS OR LESS THAN 3.0 x 10^6 CELLS SURVIVED TO BE CLONED; OTHER THAN 300 CELLS USED FOR VIABLE CLONES -- VALUES FOR RELATIVE CLONING EFFICIENCY AND PERCENT RELATIVE GROWTH ADJUSTED ACCORDINGLY.

4. SUMMARY OF MOUSE LYMPHOMA (L5178Y) RESULTS TABLE 2

A. NAME OR CODE DESIGNATION OF THE TEST COMPOUND: PICRAMIC ACID
B. LBI CODE #: 3736
C. SOLVENT: DIMETHYL SULFOXIDE
D. TEST DATE: 02/12/79

TEST	S-9 SOURCE	S-9 TISSUE	DAILY COUNTS (CELLS/ML X 10E5) 1	2	3	RELATIVE SUSPENSION GROWTH (% OF CONTROL)	TOTAL MUTANT CLONES	TOTAL VIABLE CLONES	RELATIVE CLONING EFFICIENCY (% OF CONTROL)	PERCENT RELATIVE GROWTH*	MUTANT FREQUENCY** (X 10E-6)
NONACTIVATION											
SOLVENT CONTROL	---	---	8.0	14.8		100.0	37.0	277.0	100.0	100.0	13.4
SOLVENT CONTROL	---	---	7.6	15.8		100.0	38.0	212.0	100.0	100.0	17.9
UNTREATED CONTROL	---	---	9.8	9.6		78.9	35.0	276.0	112.9	89.1	12.7
EMS .5 UL/ML	---	---	5.4	9.0		40.8	710.0 +	152.0	62.2	25.3	467.1
TEST COMPOUND											
30.000 UG/ML	---	---	7.2	6.8		41.1	35.0	230.0	94.1	38.6	15.2
100.000 UG/ML	---	---	4.4	6.8		25.1	65.0	239.0	97.8	24.5	27.2
120.000 UG/ML	---	---	4.2	4.6		16.2	66.0	274.0	112.1	18.2	24.1
150.000 UG/ML	---	---	2.8	3.6		9.1	63.0	320.0	130.9	11.9	19.7
200.000 UG/ML	---	---	2.2	3.6		9.1	39.0	305.0	124.7	11.3	12.8
ACTIVATION											
SOLVENT CONTROL	RAT	LIVER	7.2	15.8		100.0	38.0	214.0	100.0	100.0	17.8
SOLVENT CONTROL	RAT	LIVER	7.6	13.0		100.0	49.0	339.0	100.0	100.0	14.5
UNTREATED CONTROL	RAT	LIVER	7.2	12.2		82.6	60.0	303.0	109.6	90.6	19.8
DMN .3 UL/ML	RAT	LIVER	5.0	9.6		45.2	258.0	52.0	18.8	8.5	496.2
TEST COMPOUND											
15.000 UG/ML	RAT	LIVER	9.4	8.8		77.8	61.0	235.0	85.0	66.2	26.0
75.000 UG/ML	RAT	LIVER	7.6	13.4		95.8	44.0	192.0	69.4	66.5	22.9
100.000 UG/ML	RAT	LIVER	3.8	13.2		37.3	73.0	239.0	86.4	32.2	30.5
120.000 UG/ML	RAT	LIVER	4.2	12.4		49.0	92.0 +	290.0	104.9	51.4	31.7
150.000 UG/ML	RAT	LIVER	2.4	6.8		19.2	99.0	278.0	100.5	19.3	35.6

* (RELATIVE SUSPENSION GROWTH X RELATIVE CLONING EFFICIENCY) / 100
** THE RATIO OF CELLS SEEDED FOR MUTANT SELECTION TO CELLS SEEDED FOR CLONING EFFICIENCY IS 10E+4.
THEREFORE THE MUTANT FREQUENCY IS: (TOTAL MUTANT CLONES/TOTAL VIABLE CLONES)*10E-4.
THE MUTANT FREQUENCY IS GIVEN IN UNITS OF 10E-6.

\+ = ONE PLATE CONTAMINATED; VALUE BASED ON REMAINING TWO PLATES.

PROTOCOL NO. 431

1. OBJECTIVE

The objective of this study is to evaluate the test material for its ability to induce forward mutation in the L5178Y TK+/- mouse lymphoma cell line, as assessed by colony growth in the presence of 5-bromo-2'-deoxyuridine (BrdU).

2. RATIONALE

Thymidine kinase (TK) is a cellular enzyme that allows cells to salvage thymidine from the surrounding medium for use in DNA synthesis. If a thymidine analog such as BrdU is included in the growth medium, the analog will be phosphorylated via the TK pathway and be incorporated into DNA, eventually resulting in cellular death. Cells which are heterozygous at the TK locus (TK+/-) may undergo a single step forward mutation to the TK -/- genotype in which little or no TK activity remains. Such mutants are as viable as the heterozygotes in normal medium because DNA synthesis proceeds by de novo synthetic pathways that do not involve thymidine as an intermediate. The basis for selection of the TK-/- mutants is the lack of any ability to utilize toxic analogs of thymidine, which enables only the TK-/- mutants to grow in the presence of BrdU. Cells which grow to form colonies in the presence of BrdU are therefore assumed to have mutated, either spontaneously or by the action of a test substance, to the TK-/- genotype.

3. MATERIALS

A. Indicator Cells

The mouse lymphoma cell line, L5178Y TK+/-, used in this assay is derived from the Fischer L5178Y line of Dr. Donald Clive. Stocks are maintained in liquid nitrogen and laboratory cultures are periodically checked for the absence of mycoplasma contamination by culturing methods. To reduce the negative control frequency (spontaneous frequency) of TK-/- mutants to as low level as possible, cell cultures are exposed to conditions which select against the TK-/- phenotype (exposure to methotrexate) and are then returned to normal growth medium for three or more days before use.

B. Media

The cells are maintained in Fischer's mouse leukemia medium supplemented with L-glutamine, sodium pyruvate, and horse serum (10% by volume). Cloning medium consists of the preceding growth medium with the addition of agar to a final concentration of 0.35% to achieve a semisolid state. Selection medium is cloning medium containing 50 or 100 µg/ml of BrdU.

3. MATERIALS (continued)

C. Control Compounds

1. Negative Controls

A negative control consisting of assay procedures performed on untreated cells is performed in all cases. If the test compound is not soluble in growth medium, an organic solvent (normally DMSO) is used; the final concentration of solvent in the growth medium will be 1% or less. Cells exposed to solvent in the medium are also assayed as the solvent negative control to determine any effects on survival or mutation caused by the solvent alone. For test substances assayed with activation, the untreated and solvent negative controls will include the activation mixture.

2. Positive Controls

Ethylmethane sulfonate (EMS) is highly mutagenic via alkylation of cellular DNA and will be used at 0.5 µl/ml as a positive control for nonactivation studies.

Dimethylnitrosamine (DMN) requires metabolic activation by microsomal enzymes to become mutagenic and will be used at 0.3 µl/ml as a positive control for assays performed with activation.

D. Sample Forms

Solid materials are dissolved in growth medium, if possible, or in DMSO, unless another solvent is requested. Liquids are tested by direct addition to the test system at predetermined concentrations or following dilution in a suitable solvent.

4. EXPERIMENTAL DESIGN

A. Dosage Selection (Cytotoxicity testing)

The solubility of the test chemical in growth medium and/or DMSO is first determined. Then a wide range of chemical concentrations is tested for cytotoxicity, starting with a maximum applied dose of 10 mg/ml for test chemicals soluble in media or 1 mg/ml for solutions in organic solvents. After an exposure time of four hours, the cells are washed and a viable cell count is obtained the next day. Relative cytotoxicities expressed as the reduction in growth compared to the growth of untreated cells are used to select seven to ten doses that cover the range from 0 to 50-90% reduction in 24-hour growth. These selected doses are subsequently applied to cell cultures prepared for mutagenicity testing, but only four or five of the doses will be carried through the mutant selection process. This procedure compensates for daily variations in cellular cytotoxicity and ensures the choice of four or five doses spaced from 0 to 50-90% reduction in cell growth.

B. Mutagenicity Testing

1. Nonactivation Assay

The procedure used is based on that reported by Clive and Spector (1975) and is summarized as follows. Cultures exposed to the test chemical for four hours at the preselected doses are washed and placed in growth medium for two or three days to allow recovery, growth and expression of the induced TK-/- phenotype. Cell counts are determined daily and appropriate dilutions are made to allow optimal growth rates.

At the end of the expression period, 3×10^6 cells for each selected dose are seeded in soft agar plates with selection medium and resistant (mutant) colonies are counted after 10 days incubation. To determine the actual number of cells capable of forming colonies, a portion of the cell suspension is also cloned in normal medium (nonselective). The ratio of resistant colonies to total viable cell number is the mutant frequency.

A detailed flow diagram for the mutation assay is provided in Figure 1.

2. Activation Assay

The activation assay can be run concurrently with the nonactivation assay. The only difference is the addition of the S9 fraction of rat liver homogenate and necessary cofactors (CORE) during the four-hour treatment period. CORE consists of NADP (sodium salt) and isocitric acid. The final concentrations of the activation system components in the cell suspension are: 2.4 mg NADP/ml; 4.5 mg isocitric acid/ml; and 50 µl S9/ml.

C. Preparation of 9,000 x g Supernatant (S9)

Fischer 344 male rats are normally used as the source of hepatic microsomes. Induction with Aroclor 1254 or other agents is performed by injections five days prior to sacrifice. After decapitation and bleeding, the liver is immediately dissected from the animal using aseptic technique and placed in ice cold 0.25M sucrose buffered with Tris at pH 7.4. When an adequate number of livers is obtained, the collection is washed twice with fresh buffered sucrose and completely homogenized. The homogenate is centrifuged for 10 minutes at 9,000 x g in a refrigerated centrifuge and the supernatant (S9) from this centrifuged sample is retained and frozen at -80°C until used in the activation system. The S9 fraction may be obtained from induced or noninduced rats or other species, as requested.

EVALUATION CRITERIA

A compound is considered mutagenic in this assay if:

- A dose-response relationship is observed over 3 of the 5 dose levels employed.
- The minimum increase at the low level of the dose-response curve is at least 2.5 times greater than the solvent and/or negative control values.
- The solvent and negative control data are within the normal range of the spontaneous background for the TK locus.

All evaluations of mutagenic activity are based on consideration of the concurrent solvent and negative control values run with the experiment in question. Positive control values are not used as reference points, but are included to ensure that the current cell population responds to direct and promutagens under the appropriate treatment conditions.

Occasionally, a single point within a concentration range will show an increase 2.5 times greater than the spontaneous background. If the increase is at the high dose, is reproducible, and if an additional higher dose level is not feasible because of toxicity, the chemical can be considered mutagenic. If the increase is internal within the dose range and is not reproducible, the increase will normally be considered aberrant. If the internal increase is reproducible, several doses clustered around the positive concentration will be examined to either confirm or reject the reliability of the effect.

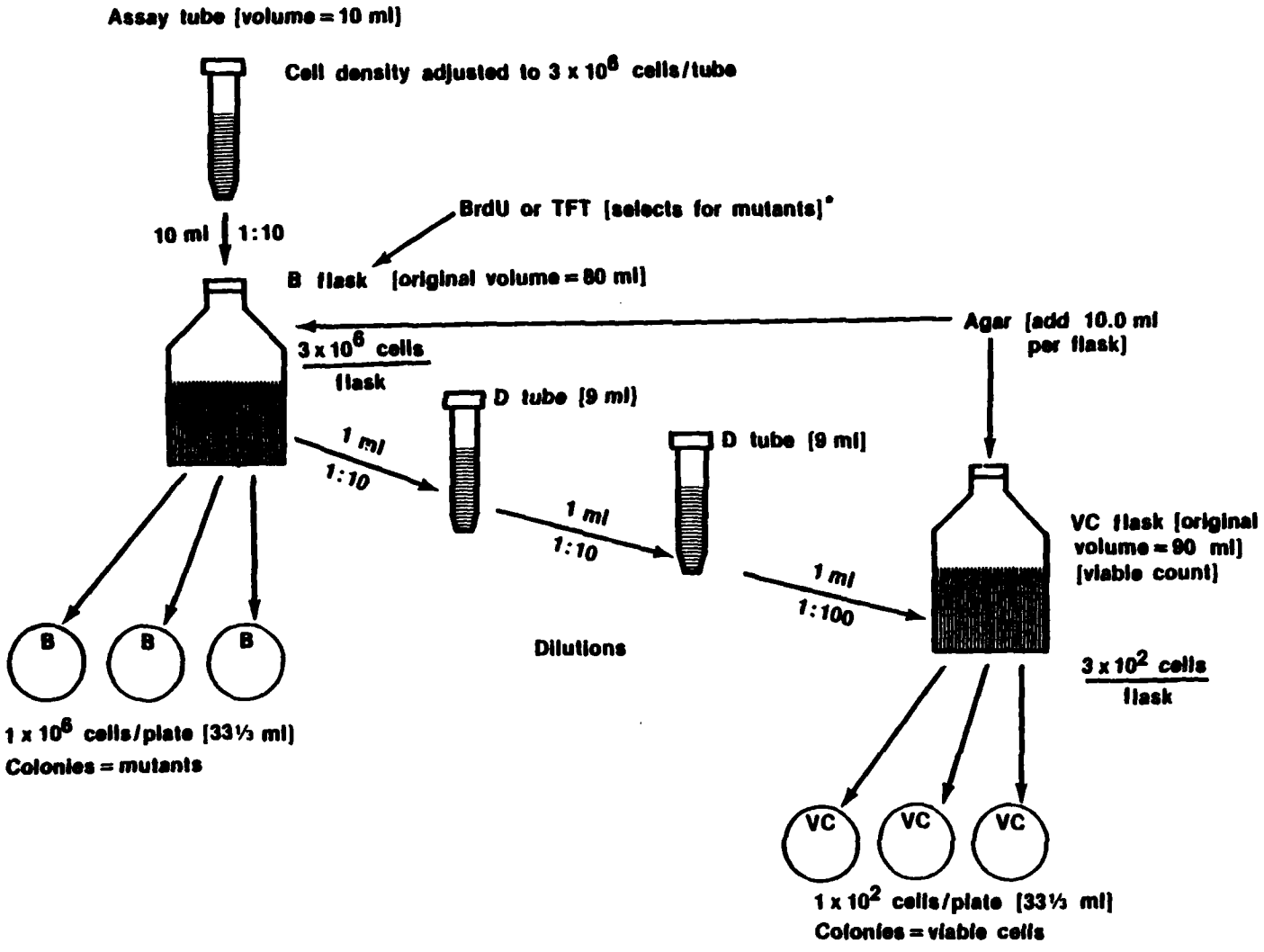
As the data base on the assay increases, the evaluation criteria can be expected to become more firmly established.

5. REPORT

The screened doses, cell counts, and mutant and viable colony counts will be entered into a computer program. The results are analyzed and printed.

6. REFERENCE

Clive, D. and Spector, J.F.S.: Laboratory procedure for assessing specific locus mutations at the TK locus in cultured L5178Y mouse lymphoma cells. Mutation Res., 31:17-29, 1975.



*Added after removal of 1 ml for viable count dilutions.

FIGURE 1. LYMPHOMA CLONING FLOW CHART

GENETICS ASSAY #3736

MUTAGENICITY EVALUATION OF

PICRAMIC ACID

IN THE
SISTER CHROMATID EXCHANGE ASSAY
IN L5178Y MOUSE LYMPHOMA CELLS

SEGMENT REPORT

SUBMITTED TO:

U.S. NAVY
800 N. QUINCY STREET
ARLINGTON, VA. 22217

SUBMITTED BY:

LITTON BIONETICS, INC.
5516 NICHOLSON LANE
KENSINGTON, MARYLAND 20795

LBI PROJECT NO: 20990

MARCH 1979

Litton BIONETICS

PREFACE

This report contains a summary of the data compiled during the evaluation of the test compound. The report is organized to present the results in a concise and easily interpretable manner. The first part contains items I-VIII. Items I-IV provide sponsor and compound identification information, type of assay, and the protocol reference number. All protocol references indicate a standard procedure described in the Litton Bionetics, Inc. "Screening Program for the Identification of Potential Mutagens and Carcinogens." Item V provides the initiation and completion dates for the study. Item VI identifies the tables and/or figures containing the data used by the study director in interpreting the test results. The interpretation itself is in Item VII. Item VIII provides the conclusion and evaluation.

The second part of the report, entitled PROTOCOL, describes the materials and procedures employed in conducting the assay. This part of the report also contains evaluation criteria used by the study director, and any appendices.

All test and control results presented in this report are supported by raw data which are permanently maintained in the files of the Department of Genetics and Cell Biology or in the archives of Litton Bionetics, Inc., 5516 Nicholson Lane, Kensington, Maryland, 20795.

Copies of the raw data will be supplied to the sponsor upon request. Copies of raw data are provided in the appendix.

I. SPONSOR: U.S. Navy

II. MATERIAL TESTED

A. Client's Identification: Picramic Acid

B. Genetic's Assay No.: #3736

C. Date Received: November 7, 1978

D. Physical Description: Brown powder

III. TYPE OF ASSAY: Sister Chromatid Exchange Assay

IV. PROTOCOL NO.: 433

V. STUDY DATES:

A. Initiation Date: January 17, 1979

B. Completion Date: February 5, 1979

VI. RESULTS

The results of this assay are presented in Tables 1 and 2.

VII. INTERPRETATION OF RESULTS:

The test compound, Picramic Acid, was evaluated for its ability to induce SCEs directly and also in the presence of a metabolic activation system that contains liver microsomal enzymes from Aroclor-induced rats.

Prior to dosing, a stock solution of Picramic Acid was prepared in DMSO at 8 mg/ml. Serial dilutions were performed using the same solvent so that the desired dose levels could be achieved using solution concentrations (in medium) that did not exceed 0.01 ml/ml.

Metabolic activation had no appreciable effect on toxicity (see Protocol) and dose levels were therefore identical in the activation and nonactivation assays. Picramic Acid was clearly negative in these studies, as no significant increases in SCE frequency were observed (Tables 1 and 2). There was no suggestion of a positive dose response. Significant increases in SCE frequency were observed in the positive controls, and negative controls were within the normal range, so it is clear that the test systems were functioning properly.

VIII. CONCLUSIONS:

Picramic Acid does not induce SCE under the conditions of this investigation.

Submitted by:

Study Director

Daniel Stetka 4/4/79

Daniel Stetka, Ph.D. Date
Section Leader
Animal Genetics and
Cytogenetics
Department of Genetics
and Cell Biology

Reviewed by:

David J. Brusick 4/4/79

David J. Brusick, Ph.D. Date
Director
Department of Genetics
and Cell Biology

Litton BIONETICS

TABLE 1

SCE FREQUENCIES IN CELLS EXPOSED TO PICRAMIC ACID

WITHOUT METABOLIC ACTIVATION

Treatment	Dose	No. of Chromosomes †	No. of SCE's	SCE/Chromosome ±SE	SCE/Cell
Negative Control (Medium)	---	737	184	0.250 ± 0.018	9.99
Positive Control (EMS)	0.5 µl/ml	701	762	1.087 ± 0.039*	43.48*
Solvent Control (DMSO)	0.1 ml/tube	763	172	0.225 ± 0.017	9.02
Test Compound					
Picramic Acid	0.625 µg/ml	738	184	0.249 ± 0.018	9.97
Picramic Acid	1.250 µg/ml	774	166	0.214 ± 0.017	8.58
Picramic Acid	2.500 µg/ml	766	191	0.249 ± 0.018	9.97
Picramic Acid	5.000 µg/ml	764	200	0.262 ± 0.019	10.47
Picramic Acid	10.000 µg/ml	743	178	0.240 ± 0.018	9.58
Picramic Acid	20.000 µg/ml	752	216	0.287 ± 0.020	11.49

†20 cells scored for each treatment

*Significantly greater than solvent control value at $P < 0.01$ (t-test)

TABLE 2

SCE FREQUENCIES IN CELLS EXPOSED TO PICRAMIC ACID

WITH METABOLIC ACTIVATION

Treatment	Dose	No. of Chromosomes†	No. of SCE's	SCE/Chromosome ±SE	SCE/Cell
Negative Control (Medium)	---	738	188	0.255 ± 0.019	10.19
Positive Control (DMN)	0.3 µl/ml	598	467	0.781 ± 0.036*	31.24*
Solvent Control (DMSO)	0.1 ml/tube	735	206	0.280 ± 0.019	11.21
Test Compound					
Picramic Acid	0.625 µg/ml	747	264	0.353 ± 0.022	14.14
Picramic Acid	1.250 µg/ml	744	199	0.267 ± 0.019	10.70
Picramic Acid	2.500 µg/ml	747	193	0.258 ± 0.019	10.33
Picramic Acid	5.000 µg/ml	756	213	0.282 ± 0.019	11.27
Picramic Acid	10.000 µg/ml	742	204	0.275 ± 0.019	11.00
Picramic Acid	20.000 µg/ml	749	217	0.290 ± 0.020	11.59

†20 cells scored for each treatment except positive controls where 16 were scored.

*Significantly greater than solvent control value at $P < 0.01$ (t-test).

PROTOCOL

1. OBJECTIVE

The objective of this study was to evaluate Picramic Acid for Sister Chromatid Exchange (SCE) induction in L5178Y mouse lymphoma cells.

2. MATERIALS AND METHODS

A. Toxicity

The solubility, toxicity, and doses for all chemicals were determined prior to screening. The effect of each chemical on the survival of the indicator cells was determined by exposing the cells to a wide range of chemical concentrations in complete growth medium. Toxicity was measured as loss in growth potential of the cells induced by a four-hour exposure to the chemical followed by a 24-hour expression period in growth medium. A minimum of four doses was selected from the range of concentrations by using the highest dose that showed no loss in growth potential as the penultimate dose and by bracketing this with one higher dose and at least two lower doses.

B. Indicator Cells

The cells used in this study were derived from Fischer mouse lymphoma cell line L5178Y. The cells are heterozygous for a specific autosomal mutation at the TK locus and are bromodeoxyuridine (BrdU) sensitive.

C. Media

The cells were maintained in Fischer's medium for leukemic cells of mice with 10% horse serum and sodium pyruvate.

D. Control Compounds

1. Negative Control

The solvent in which the test compound was prepared was used as the solvent or vehicle control and is designated as solvent control in the data table. The actual solvent is listed in Table 1 of Section V. Results. A negative control consisting of cells exposed to media only is also used in the assay.

2. MATERIALS AND METHODS (continued)

D. Control Compounds

2. Positive Control

Ethylmethanesulfonate (EMS), which induces mutation by base-pair substitution, was dissolved in culture medium and used as a positive control for the nonactivation studies at a final concentration of 0.5 µl/ml.

Dimethylnitrosamine (DMN), which induces mutation by base-pair substitution and requires metabolic biotransformation by microsomal enzymes, was used as a positive control substance for activation studies at a final concentration of 0.3 µl/ml.

E. Cell Treatment

Mouse lymphoma cells (L5178Y) were treated as described below. The test compound was added to aliquots of 3 million cells in growth medium at the predetermined doses with or without an S-9 activation mixture and incubated at 37°C for 4 hours on a rocker. The incubation period was terminated by washing the cells twice with growth medium. BrdU (0.1 mM final concentration) was then added to the culture tubes and incubation was continued in the dark for 20 hours or two cell cycles. This permits BrdU to be incorporated into the DNA through two replication cycles so that sister chromatid exchanges may be detected.

Colcemid was added to a concentration of 2×10^{-7}M during the last 3 hours of incubation, and metaphase cells collected by centrifugation. Treated cells were harvested in 0.075 M KCL fixed in Carnoy's fixative and air-dried onto microscope slides.

Sister chromatid exchanges were visualized by staining with techniques described in Stetka et al (Mutat. Res. 51, 1978).

F. Activation System

1. S9 Mixture

Component	Final Concentration/ml
NADP (Sodium salt)	2.4 mg
Isocitric acid	4.5 mg
Homogenate S9 fraction	15 µl

2. S9 Homogenate

A 9,000 x g supernatant was prepared from Fischer 344 adult male rat liver induced by Aroclor 1254 five days prior to kill according to the procedure of Ames et al. (1975). S9 samples were coded by lot number and assayed for milligrams protein per milliliter and relative P448/P450 activity by methods described in LBI Technical Data on Rat Liver S9 Product.

3. RESULTS

The data presented in Tables 1A and 1B show the concentrations of the test compound employed and the number of SCE's per cell.

Interpretation of data is based on the relative increase in SCE with respect to dose compared to the spontaneous level. Statistical analysis of the data is made by a t-statistic.

REFERENCES

Ames, B.N., McCann, J. and Yamasake, E. (1975). Methods for detecting carcinogens and mutagens with the Salmonella/ mammalian-microsome mutagenicity test. Mutation Res. 31, 347-364.

GENETICS ASSAY # 3736

MUTAGENICITY EVALUATION OF

PICRAMIC ACID

IN THE
MOUSE BONE MARROW
CYTOGENETIC ANALYSIS

SEGMENT REPORT

SUBMITTED TO:

U.S. NAVY
800 N. QUINCY STREET
ARLINGTON, VA. 2217

SUBMITTED BY:

LITTON BIONETICS, INC.
5516 NICHOLSON LANE
KENSINGTON, MARYLAND 20795

LBI PROJECT NO. 21022

MARCH 1979

Litton BIONETICS

PREFACE

This report contains a summary of the data compiled during the evaluation of the test compound. The report is organized to present the results in a concise and easily interpretable manner. The first part contains items I-VI. Items I-IV provide sponsor and compound identification information, type of assay, and the protocol reference number. All protocol references indicate a standard procedure described in the Litton Bionetics, Inc. "Screening Program for the Identification of Potential Mutagens and Carcinogens."

Item V identifies the tables and/or figures containing the data used by the study director in interpreting the test results. The interpretation of the results and conclusions are in Item VI.

The second part of the report, entitled PROTOCOL, describes the materials and procedures employed inconducting the assay. This part of the report also contains evaluation criteria used by the study director, and any appendices.

All test and control results presented in this report are supported by raw data which are permanently maintained in the files of the Department of Genetics and Cell Biology or in the archives of Litton Bionetics, Inc., 5516 Nicholson Lane, Kensington, Maryland, 20795.

Copies of raw data will be supplied to the sponsor upon request.

I. SPONSOR: U.S. Navy

II. MATERIAL

A. Identification: Picramic Acid

B. Date Received: November 7, 1978

C. Physical Description: Brown powder

III. TYPE OF ASSAY: Mouse Bone Marrow Cytogenetic Analysis*

IV. PROTOCOL NO.: DMT-112

V. RESULTS

The toxicology and dosage selection results are presented in Table 1. The acute and subchronic test results have been collected from raw data sheets and tabulated in summary form in Table 2.

VI. INTERPRETATION OF RESULTS AND CONCLUSIONS

The test compound, Picramic Acid, was evaluated for its ability to induce chromosome aberrations in bone marrow cells of mice exposed either acutely or subchronically to various dose levels.

Preliminary range-finding studies were conducted using a wide range of doses to determine the LD_{50} for oral administration of this compound. Probit analysis indicated a value of 378 mg/kg, which would normally (under our standard protocol) require that the high dose in the cytogenetic study be 37.8 mg/kg or (1/10) x LD_{50}. The dose response was quite shallow, however, so that 37.8 mg/kg was still less than 1/5 of the LD_1. Therefore, the high dose was arbitrarily raised to twice the normal, LD_{50}-determined value (i.e., to 75.6 mg/kg, see Table 1). It was hoped that this higher dose would still provide adequate yields of scorable, metaphase bone marrow cells, and in so doing would constitute a better assay for potential clastogenicity of this compound. Lower doses were selected as 1/3 and 1/10 of the highest dose.

Picramic Acid solutions were prepared at 12.0 mg/ml in corn oil and diluted, as required, using the same solvent so that final dose levels sould be achieved with the injection of 0.2 ml/animal/dose. Dosing schedules and general experimental design are outlined in Table 3.

*Initiation Date: February 12, 1979 Completion Date: March 15, 1979

VI. INTERPRETATION OF RESULTS AND CONCLUSIONS (Continued)

Results of the cytogenetic assay are presented in Table 2. Positive control values (structural aberration frequencies and percent cells with aberrations) were elevated significantly compared to negative (solvent) controls. Picramic Acid on the other hand, was clearly not clastogenic under the conditions of this test. Structural aberration frequencies were all well within normal range following administration of this compound, and subchronic exposure resulted in frequencies of aberrations that were actually lower than the appropriate control value at all dose levels. Furthermore, not one multi-break type aberration was observed at the highest dose level.

It is now apparent that the selection of 1/5 x LD_{50} as the highest dose was warrented, since adequate yields of scorable cells were still obtained and even this relatively high dose failed to induce chromosome aberrations. The test compound did not exhibit any clastogenic activity in this assay.

Submitted by:

Study Director

Daniel Stetka, Ph.D. — 3/23/79 Date
Section Leader
Animal Genetic
and Cytogenetics
Department of Genetics
and Cell Biology

Reviewed by:

David J. Brusick, Ph.D. — 3/23/79 Date
Director
Department of Genetics
and Cell Biology

Table 1

Toxicity and Dosage Information for Picramic Acid and Control Compounds

Picramic Acid — LD_{50} determined from range-finding study is 3.78 mg/kg per os (PO), leading to the following:

High Dose (1/5 LD_{50}) = 75.6 mg/kg PO in corn oil (0.2 ml soln/mouse/dose)

Inter Dose (1/15 LD_{50}) = 25.2 mg/kg PO in corn oil (0.2 ml soln/mouse/dose)

Low Dose (1/50 LD_{50}) = 7.6 mg/kg PO in corn oil (0.2 ml soln/mouse/dose)

Negative Control* Corn oil (the solvent vehicle), administered PO at 0.2 ml/mouse/dose

Positive Control* TEM at 1 mg/kg administered IP in saline at 0.32 ml soln/mouse

*The controls were shared with the bone marrow cytogenetic evaluation of Otto Fuel (U.S. Navy)

TABLE 2

A SUMMARY OF THE CYTOGENETIC ANALYSIS OF PICRAMIC ACID

Treatment	Dose	Kill Time (Hrs)[a]	No. of Animals[b]	Total No. of Cells	Type and Number( ) of Aberrations Structural	Numerical	Structural[c] Aberration Frequency	No. of Cells with one or more Aberrations	Percent Cells with Aberrations
Picramic Acid	7.60 mg/kg	6	7	318	1tb,2f,1min(3)	1h (1)	0.013	5	1.3
		24	5	192	--- (0)	--- (0)	0.000	0	0.0
		48	7	262	2f (2)	3h,1pp (4)	0.008	6	2.3
	S.C.	6	8	306	1f (1)	--- (0)	0.003	1	0.3
	25.2 mg/kg	6	7	290	2tb,4f (6)	9h (9)	0.020	15	5.2
		24	7	307	1tb,2f (3)	5h (5)	0.010	8	2.6
		48	5	225	1td,3f (4)	-- (0)	0.018	3	1.3
	S.C.	6	8	281	1tb, 1f, 1r (3)	3h (3)	0.011	5	1.8
	75.6 mg/kg	6	8	284	1td,1f (2)	6h, 3pp (9)	0.007	11	3.9
		24	7	318	1td (1)	7h (7)	0.003	8	2.5
		48	7	194	2f (2)	--- (0)	0.010	2	1.0
	S.C.	6	5	183	1 min (1)	1h (1)	0.005	2	1.1

[a]Time after final exposure when bone marrow was harvested

[b]Includes only those animals from which at least 5 scorable metaphases were obtained

[c]No. of Aberration/No. of Cells

*P<0.05 by t-test, two-tailed

** P<0.01 by t-test, two-tailed

TABLE 2

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		48	7	262	2f (2)	3h,1pp (4)	0.008	6	2.3
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	75.6 mg/kg	6	8	284	1td,1f (2)	6h, 3pp (9)	0.007	11	3.9
		24	7	318	1td (1)	7h (7)	0.003	8	2.5
		48	7	194	2f (2)	--- (0)	0.010	2	1.0
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[a]Time after final exposure when bone marrow was harvested

[b]Includes only those animals from which at least 5 scorable metaphases were obtained

[c]No. of Aberration/No. of Cells

*P<0.05 by t-test, two-tailed

** P<0.01 by t-test two-tailed

TABLE 2

A SUMMARY OF THE CYTOGENETIC ANALYSIS OF PICRAMIC ACID

Treatment	Dose	Kill Time (Hrs)[a]	No. of Animals[b]	Total No. of Cells	Type and Number( ) of Aberrations Structural	Numerical	Structural[c] Aberration Frequency	No. of Cells with one or more Aberrations	Percent Cells with Aberrations
Negative Control	0.2 ml Corn Oil	6	8	400	2td,1f,2af(5)	1h (1)	0.013	6	1.5
		24	7	228	1tb,1td,3f(5)	-- (0)	0.022	5	2.2
		48	6	227	1td,2f (3)	2h (2)	0.013	5	2.2
	S.C.	6	6	300	1tb,4f,1af(6)	4h (4)	0.020	8	2.7
Positive Control	1.0 mg/kg	24	5	175	13tb,23td 105f 17af,6t,4tr,1qr, 9pu+,3puc,2cr,2r 5d,38> (>228)	-- (0)	>1.303**	107	61.7

[a]Time after final exposure when bone marrow was harvested

[b]Includes only those animals from which at least 5 scorable metaphases were obtained

[c]No. of Aberration/No. of Cells

*P<0.05 by t-test, two-tailed

** P<0.01 by t-test, two-tailed

ANY OF THE FOLLOWING ABBREVIATIONS MAY BE USED IN THE SUMMARY TABLES:

af = acentric fragment

cr = complex rearrangement

d = dicentric chromosome

f = fragment

h = hyperdiploid

min = minute chromosome

pp = polyploid

puc = pulverized cell

pu+ = pulverized chromosome

qr = quadriradial

r = ring

sb = chromosome break

sd = chromosome deletion

sg = chromosome gap

sl = slide lost or broken

t = translocation

tb = chromatid break

td = chromatid deletion

tg = chromatid gap

tr = triradial

> = greater than 10 aberrations

PROTOCOL

1. PURPOSE

The purpose of this study was to determine the potential genetic activity of a chemical administered to mice by examination of cells arrested at metaphase of mitosis for structural changes and rearrangements of their chromosomes.

2. MATERIALS

A. Animals

Adult, male mice (HA/ICR) purchased from Cumberland Labs were used in this cytogenetic study.

B. Control Chemicals

Triethylenemelamine (TEM) was used as the positive control compound. The negative control consisted of the solvent or vehicle used for the test compound. The concentrations and routes of administration are given in Table 1.

3. EXPERIMENTAL DESIGN

A. Animal Husbandry

The animals were group housed according to LBI standard operating procedures and offered a commercial diet (Purina) and water ad libitum unless contraindicated by the particular experimental design.

The animals were randomly assigned to experimental groups. Prior to study initiation, 10% of the animals were weighed and a mean body weight was determined for the group. Dose levels were established using this mean unless there was significant variation among individuals, in which case individual weighings and calculations were performed. Animals were identified by cage number.

3. EXPERIMENTAL DESIGN (continued)

B. Dosage Determination

Dosage information was calculated on the basis of range finding studies using 6 groups of 6 rats each. The high dose level was selected from these data. One-third and one-tenth of the high dose were used as the intermediate and low dose levels, respectively. For nontoxic compounds a maximum high dose level of 5 g/kg (or equivalent) is generally chosen.

4. METHODOLOGY

Table 3 shows the basic design of the test. Both acute (single dose) and subchronic (5 consecutive doses) sequences are provided. A total of 136 mice--104 in the acute study and 32 in the subchronic study--were used in the test as outlined in Table 3.

Two hours prior to kill, the animals were injected IP with 4.0 mg/kg colchicine. At times indicated in Table 3, mice were killed with CO_2 and the adhering soft tissue and epiphyses of one or both tibiae were removed. The marrow was aspirated from the bone and transferred to Hank's Balanced Salt Solution (HBSS). The marrow button was collected by centrifugation and then resuspended in 0.075M KCL. The centrifugation was repeated and the pellet resuspended in Carnoy's fixative. The fixative was changed after one-half hour and the cells left overnight at 4°C.

Slides were prepared by dropping the cells from the fixative onto a glass slide and the film air-dried. Spreads were stained with 10% Giemsa at pH 6.8.

Slides were coded and scored for chromosomal aberrations. Where possible, 50 spreads were read for each animal dosed.

Animals which died during dosing were not replaced unless the number of deaths at a single dose level was 4 or more. In that case, the entire dose level was repeated following consultation with the sponsor.

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TABLE 3

MOUSE BONE MARROW CYTOGENETIC ANALYSIS
NUMBER OF ANIMALS USED

Treatment	ACUTE STUDY Number of Animals Killed at 6, 24, and 48 Hr After Dosing			SUBCHRONIC STUDIES 5 Exposures-24 Hr Apart Animals Killed 6 Hr After Last Exposure	Total Animals
High Level	6 Hr	24 Hr	48 Hr	6 Hr	
High Level	8	8	8	8	32
Intermediate Level	8	8	8	8	32
Low level	8	8	8	8	32
Positive Control	-	8	-	-	8
Negative Control	8	8	8	8	32

5. EVALUATION CRITERIA

A number of general guidelines has been established to serve as an aid in determining the meaning of bone marrow chromosomal aberrations.

A. General

Basically, we were trying to establish whether a substance or its metabolites could interact with chromosomes to produce gross lesions or changes in chromosome numbers, and whether these were of a type which could survive more than one mitotic cycle of the cell. The assay design was such that bone marrow samples were taken at 6, 24, and 48 hrs afer an acute administration of the compound. Since the cell transit time for bone marrow is 20-24 hrs, one can, based on the time of kill, obtain an indication of when in the cell cycle a compound may be active.

B. Aberrations/Records

All aberration figures detected by this assay resulted from breaks in the chromatin which either failed to repair or repaired in atypical combinations. We scored and recorded on standard forms gaps, breaks, fragments, and reunion figures which involved a single chromatid or both chromitids of a single chromosome. The number and type of aberration for each cell were recorded as was the number of chromosomes for every cell located and scored. Up to 50 cells were scored on each slide. Depending on the suitability of the material, it could have been necessary to prepare additional slides from the original fixed material. The location of cells bearing aberrations was identified by the use of coordinates on the mechanical stage.

C. Data Interpretation

Data were summarized in tabular form and evaluated. Gaps were not counted as significant aberrations unless they were present at exceptionally high frequency. Open breaks were considered as indicators of genetic damage as were configurations resulting from the repair of breaks. The latter include translocations. multiradials, rings, multicentrics, etc. Reunion figures such as these were weighted slightly higher than breaks since they usually result from more than one break and may lead to stable configurations.

The number of aberrations per cell is also considered to be significant; cells with more than one aberration were considered to indicate more genetic damage than those containing evidence of single events. Consistent variations from the euploid number were also considered in the evaluation of mutagenic potential.

5. EVALUATION CRITERIA (continued)

C. Data Interpretation

Comparison with a concurrent negative control which lacks aberrations can suggest statistical significance; therefore, treatment data may also be considered against historical control data. In either event the type of aberration, its frequency, and its correlation to dose trends within a given time period, were all considered in evaluating a compound as being mutagenically positive or negative.

#3736

MUTAGENICITY EVALUATION OF PICRAMIC ACID IN THE MOUSE DOMINANT LETHAL ASSAY

SEGMENT REPORT

SUBMITTED TO:

CODE 4444
DEPT. OF NAVY
OFFICE OF NAVAL RESEARCH
ARLINGTON, VIRGINIA 22217

SUBMITTED BY:

LITTON BIONETICS, INC.
5516 NICHOLSON LANE
KENSINGTON, MARYLAND 20795

LBI PROJECT NO. 21021

APRIL 1979

Litton BIONETICS

I. SPONSOR: U.S. Navy

II. MATERIAL

A. Identification: Picramic Acid

B. Date Received: November 7, 1978

C. Physical Description: Rust colored powder

III. TYPE OF ASSAY: Mouse Dominant Lethal Assay

IV. STUDY DATES:

A. Initiation Date: January 29, 1979

B. Completion Date: April 5, 1979

V. PROTOCOL NO.: 470

VI. The results are presented in Tables 2 - 7. Table 1 provides treatment information. The remaining tables summarize test results and statistical analyses.

VII. INTERPRETATION OF RESULTS AND CONCLUSIONS:

Male mice were exposed to 7.56 mg/kg, 25.2 mg/kg and 75.6 mg/kg of Picramic Acid and mated to virgin females over the entire spermatogenic cycle. Administration of the test material was by oral gavage. Detailed dosing information is provided in Table 1.

The results of the dominant lethal scoring are given in Tables 2-7 and cover all significant parameters of mating, fertility and fetal wastage.

Fertility-All fertility data were within the historical range and no compound related effects were observed.

Implants per pregnant female:The positive control values for week 2 were significantly reduced, otherwise all data were within the historical range.

Dead implants per pregnant female:TEM demonstrated a significant response over weeks 1-4. The low dose of the test material at week 3 was also increased but was not considered indicative of dominant lethality. All other test data were within the historical range.

Females with one or more dead implants:The positive control values were slightly elevated compared to the negative control data. Only week 2 positive control results were significant. These data indicate a relatively uniform distribution of dead implants.

VI. INTERPRETATION OF RESULTS AND CONCLUSIONS (Continued)

Females with two or more dead implants: The positive control values for weeks 1-4 were highly significant indicating a strong response with TEM. All other test data were within the normal range. These data suggest a relatively uniform distribution of dead implants in the test groups.

Dead implants per total implants: TEM showed a dominant lethal effect in weeks 1, 2 and 3. All test material data were within the range of the historical negative controls.

Picramic Acid was not active in the dominant lethal assay conducted in mice.

Submitted by:

Study Director

Sam Ruy for 5-1-79

Daniel Stetka, Ph.D. Date
Section Leader
Animal Genetics
and Cytogenetics
Department of Genetics
and Cell Biology

Reviewed by:

David J. Brusick 5/1/79

David J. Brusick, Ph.D. Date
Director
Department of Genetics
and Cell Biology

Litton BIONETICS

Table 1

Sponsor U.S. Navy | Study ID Mouse Dominant Lethal | Initiation Date January 29, 1979

Project No. 21021 | Strain/Species CD-1 Mice | Termination Date April 5, 1979

Compound Picramic Acid | Breeder Charles River | Location Kensington

Assay No. 3736 | Purchase Order No. 87857 | Room Nos. L, 5X

Treatment	Vehicle	Dosage[B]	Route of Administration	Volume/ Animal [ml]	Number of Administrations	Animal Numbers
Picramic Acid	Corn Oil	7.56 mg/kg	PO	0.2	5	9803-9812
Picramic Acid	Corn Oil	25.2 mg/kg	PO	0.2	5	9813-9822
Picramic Acid	Corn Oil	75.6 mg/kg	PO	0.2	5	9823-9832
Corn Oil	--	6.0 ml/kg	PO	0.2	5	9893-9902
TEM	0.85% Saline	0.35 mg/kg	IP	0.12	1	9913-9922

Supervisory Personnel: Gary Roy

A Dosage levels based on client provided information.
B Dosage levels based on LD_{50} determination.
C Toxic signs noted:

TABLE 2

FERTILITY INDEX

COMPOUND: PICRAMIC ACID 3736 STUDY: SUBCHRONIC SPECIES: MICE

WEEK	HIST. NEG. CONT.	NEG. CONTROL	POS. CONTROL	7.5600 MG/KG	25.2000 MG/KG	75.6000 MG/KG	LOG DOSE	ARITH DOSE
1	567/1000 = 0.57	7/ 16 = 0.44	10/ 20 = 0.50	14/ 20 = 0.70	7/ 20 = 0.35	12/ 18 = 0.67		
2	730/1040 = 0.70	12/ 16 = 0.75	14/ 20 = 0.70	10/ 20 = 0.50	12/ 20 = 0.60	9/ 17 = 0.53		
3	694/1030 = 0.69	13/ 16 = 0.81	13/ 20 = 0.65	13/ 20 = 0.65	13/ 20 = 0.65	12/ 17 = 0.71		
4	684/1002 = 0.68	12/ 16 = 0.75	16/ 20 = 0.80	15/ 20 = 0.75	17/ 20 = 0.85	14/ 18 = 0.78		
5	637/ 999 = 0.64	12/ 14 = 0.86	18/ 20 = 0.90	17/ 20 = 0.85	16/ 20 = 0.80	13/ 17 = 0.77		
6	669/1000 = 0.67	6/ 16 = 0.38	18/ 20 = 0.90**	9/ 19 = 0.47	11/ 20 = 0.55	10/ 18 = 0.56		
7	630/ 960 = 0.66	13/ 16 = 0.81	14/ 20 = 0.70	14/ 20 = 0.70	12/ 20 = 0.60	9/ 17 = 0.53		

NOTE: THE SYMBOL * DENOTES ANY SIGNIFICANT DIFFERENCE AT THE DOSE LEVELS COMPARED WITH THE NEGATIVE CONTROL.

THE TWO COLUMNS IDENTIFIED AS LOG DOSE AND ARITHMETIC DOSE ARE USED TO NOTE ANY SIGNIFICANT DEVIATION OF THE SLOPE OF THE REGRESSION LINE FROM ZERO.

SIGNIFICANCE IN THE LOG DOSE COLUMN IS CALCULATED USING THE LEVELS OF THE TEST COMPOUND, WHEREAS THE SIGNIFICANCE IN THE ARITHMETIC DOSE COLUMN ALSO INCLUDES THE NEGATIVE CONTROL.

ONE * OR $ INDICATES SIGNIFICANCE AT P LESS THAN 0.05.
TWO * OR $ INDICATES SIGNIFICANCE AT P LESS THAN 0.01.

TABLE 3

AVERAGE NUMBER OF IMPLANTATIONS PER PREGNANT FEMALE

COMPOUND: PICRAMIC ACID 3736 STUDY: SUBCHRONIC SPECIES: MICE

WEEK	HIST. NEG. CONT.	NEG. CONTROL	POS. CONTROL	7.5600 MG/KG	25.2000 MG/KG	75.6000 MG/KG	LOG DOSE	ARITH DOSE
1	6602/ 567 = 11.64	77/ 7 = 11.00	90/ 10 = 9.00	175 / 14 = 12.50	85/ 7 = 12.14	125 / 12 = 10.42	$	
2	8530/ 730 = 11.68	138/ 12 = 11.50	83/ 14 = 5.93**	119/ 10 = 11.90	137/ 12 = 11.42	99/ 9 = 11.00		
3	8284/ 694 = 11.94	138/ 13 = 10.62	154/ 13 = 11.85	154/ 13 = 11.85	147/ 13 = 11.31	142 / 12 = 11.83		
4	8079/ 694 = 11.81	129/ 12 = 10.75	174/ 16 = 10.88	174/ 15 = 11.60	187/ 17 = 11.00	137 / 14 = 9.79		
5	7507/ 637 = 11.78	146/ 12 = 12.17	199/ 18 = 11.06	205/ 17 = 12.06	184/ 16 = 11.50	159/ 13 = 12.23		
6	8151/ 669 = 12.18	60/ 6 = 10.00	199/ 18 = 11.06	105/ 9 = 11.67	120/ 11 = 10.91	106/ 10 = 10.60		
7	7693/ 630 = 12.22	170/ 13 = 13.08	171/ 14 = 12.21	172/ 14 = 12.29	139/ 12 = 11.58	120/ 9 = 13.33		

NOTE: THE SYMBOL * DENOTES ANY SIGNIFICANT DIFFERENCE AT THE DOSE LEVELS COMPARED WITH THE NEGATIVE CONTROL.

THE TWO COLUMNS IDENTIFIED AS LOG DOSE AND ARITHMETIC DOSE ARE USED TO NOTE ANY SIGNIFICANT DEVIATION OF THE SLOPE OF THE REGRESSION LINE FROM ZERO.

SIGNIFICANCE IN THE LOG DOSE COLUMN IS CALCULATED USING THE LEVELS OF THE TEST COMPOUND, WHEREAS THE SIGNIFICANCE IN THE ARITHMETIC DOSE COLUMN ALSO INCLUDES THE NEGATIVE CONTROL.

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TWO * OR $ INDICATES SIGNIFICANCE AT P LESS THAN 0.01.

TABLE 4

AVERAGE RESORPTIONS (DEAD IMPLANTS) PER PREGNANT FEMALE
COMPOUND: PICRAMIC ACID 3736 STUDY: SUBCHRONIC SPECIES: MICE

WEEK	HIST. NEG. CONT.	NEG. CONTROL	POS. CONTROL	7.5600 MG/KG	25.2000 MG/KG	75.6000 MG/KG	LOG DOSE	ARITH DOSE
1	378/ 567 = 0.67	8/ 7 = 1.14	54/ 10 = 5.40**	14/ 14 = 1.00	10/ 7 = 1.43	20/ 12 = 1.67		
2	616/ 730 = 0.84	10/ 12 = 0.83	58/ 14 = 4.14**	8/ 10 = 0.80	5/ 12 = 0.42	8/ 9 = 0.89		
3	518/ 694 = 0.75	7/ 13 = 0.54	27/ 13 = 2.08**	18/ 13 = 1.38*	6/ 13 = 0.46	11/ 12 = 0.92		
4	544/ 684 = 0.80	5/ 12 = 0.42	26/ 16 = 1.63*	11/ 15 = 0.73	13/ 17 = 0.76	12/ 14 = 0.86		
5	397/ 637 = 0.62	5/ 12 = 0.42	13/ 18 = 0.72	14/ 17 = 0.82	15/ 16 = 0.94	9/ 13 = 0.69		
6	508/ 669 = 0.76	3/ 6 = 0.50	8/ 18 = 0.44	3/ 9 = 0.33	5/ 11 = 0.45	5/ 10 = 0.50		
7	380/ 630 = 0.60	9/ 13 = 0.69	5/ 14 = 0.36	6/ 14 = 0.43	4/ 12 = 0.33	12/ 9 = 1.33		

NOTE: THE SYMBOL * DENOTES ANY SIGNIFICANT DIFFERENCE AT THE DOSE LEVELS COMPARED WITH THE NEGATIVE CONTROL.

THE TWO COLUMNS IDENTIFIED AS LOG DOSE AND ARITHMETIC DOSE ARE USED TO NOTE ANY SIGNIFICANT DEVIATION OF THE SLOPE OF THE REGRESSION LINE FROM ZERO.

SIGNIFICANCE IN THE LOG DOSE COLUMN IS CALCULATED USING THE LEVELS OF THE TEST COMPOUND, WHEREAS THE SIGNIFICANCE IN THE ARITHMETIC DOSE COLUMN ALSO INCLUDES THE NEGATIVE CONTROL.

ONE * OR $ INDICATES SIGNIFICANCE AT P LESS THAN 0.05.
TWO * OR $ INDICATES SIGNIFICANCE AT P LESS THAN 0.01.

TABLE 5

PROPORTION OF FEMALES WITH ONE OR MORE DEAD IMPLANTATIONS
COMPOUND: PICRAMIC ACID 3736 STUDY: SUBCHRONIC SPECIES: MICE

WEEK	HIST. NEG. CONT.	NEG. CONTROL	POS. CONTROL	7.5600 MG/KG	25.2000 MG/KG	75.6000 MG/KG	LOG DOSE	ARITH DOSE
1	369/ 567 = 0.44	5/ 7 = 0.71	10/ 10 = 1.00	8/ 14 = 0.57	7/ 7 = 1.00	8/ 12 = 0.67		
2	273/ 730 = 0.37	7/ 12 = 0.58	14/ 14 = 1.00*	4/ 10 = 0.40	5/ 12 = 0.42	6/ 9 = 0.67		
3	319/ 696 = 0.46	6/ 13 = 0.46	10/ 13 = 0.77	9/ 13 = 0.69	4/ 13 = 0.31	6/ 12 = 0.50		
4	342/ 684 = 0.50	5/ 12 = 0.42	10/ 16 = 0.63	9/ 15 = 0.60	10/ 17 = 0.59	5/ 14 = 0.36		
5	250/ 637 = 0.39	4/ 12 = 0.33	7/ 18 = 0.39	9/ 17 = 0.53	9/ 16 = 0.56	9/ 13 = 0.69		
6	319/ 669 = 0.48	3/ 6 = 0.50	6/ 18 = 0.33	3/ 9 = 0.33	4/ 11 = 0.36	5/ 10 = 0.50		
7	267/ 639 = 0.42	7/ 13 = 0.54	5/ 14 = 0.36	4/ 14 = 0.29	3/ 12 = 0.25	7/ 9 = 0.78	$	

NOTE: THE SYMBOL * DENOTES ANY SIGNIFICANT DIFFERENCE AT THE DOSE LEVELS COMPARED WITH THE NEGATIVE CONTROL.

THE TWO COLUMNS IDENTIFIED AS LOG DOSE AND ARITHMETIC DOSE ARE USED TO NOTE ANY SIGNIFICANT DEVIATION OF THE SLOPE OF THE REGRESSION LINE FROM ZERO.

SIGNIFICANCE IN THE LOG DOSE COLUMN IS CALCULATED USING THE LEVELS OF THE TEST COMPOUND, WHEREAS THE SIGNIFICANCE IN THE ARITHMETIC DOSE COLUMN ALSO INCLUDES THE NEGATIVE CONTROL.

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TWO * OR $ INDICATES SIGNIFICANCE AT P LESS THAN 0.01.

TABLE 6

PROPORTION OF FEMALES WITH TWO OR MORE DEAD IMPLANTATIONS
COMPOUND: PICRAMIC ACID 3736 STUDY: SUBCHRONIC SPECIES: MICE

WEEK	HIST. NEG. CONT.	NEG. CONTROL	POS. CONTROL	7.5600 MG/KG	25.2000 MG/KG	75.6000 MG/KG	LOG DOSE	ARITH DOSE
1	96/ 567 = 0.17	2/ 7 = 0.29	8/ 10 = 0.8*	4/ 14 = 0.29	2/ 7 = 0.29	6/ 12 = 0.50		
2	131/ 730 = 0.18	3/ 12 = 0.25	11/ 14 = 0.79**	2/ 10 = 0.20	0/ 12 = 0.0	2/ 9 = 0.22		
3	108/ 696 = 0.16	1/ 13 = 0.08	9/ 13 = 0.69**	5/ 13 = 0.38	2/ 13 = 0.15	2/ 12 = 0.17		
4	122/ 684 = 0.18	0/ 12 = 0.0	7/ 16 = 0.44*	2/ 15 = 0.13	2/ 17 = 0.12	3/ 14 = 0.21		
5	88/ 637 = 0.14	1/ 12 = 0.08	3/ 18 = 0.17	2/ 17 = 0.12	5/ 16 = 0.31	0/ 13 = 0.0		
6	108/ 669 = 0.16	0/ 6 = 0.0	2/ 18 = 0.11	0/ 9 = 0.0	1/ 11 = 0.09	0/ 10 = 0.0		
7	75/ 630 = 0.12	2/ 13 = 0.15	0/ 14 = 0.0	1/ 14 = 0.07	1/ 12 = 0.08	2/ 9 = 0.22		

NOTE: THE SYMBOL * DENOTES ANY SIGNIFICANT DIFFERENCE AT THE DOSE LEVELS COMPARED WITH THE NEGATIVE CONTROL.

THE TWO COLUMNS IDENTIFIED AS LOG DOSE AND ARITHMETIC DOSE ARE USED TO NOTE ANY SIGNIFICANT DEVIATION OF THE SLOPE OF THE REGRESSION LINE FROM ZERO.

SIGNIFICANCE IN THE LOG DOSE COLUMN IS CALCULATED USING THE LEVELS OF THE TEST COMPOUND, WHEREAS THE SIGNIFICANCE IN THE ARITHMETIC DOSE COLUMN ALSO INCLUDES THE NEGATIVE CONTROL.

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TWO * OR $ INDICATES SIGNIFICANCE AT P LESS THAN 0.01.

TABLE 7

DEAD IMPLANTS / TOTAL IMPLANTS
COMPOUND: PICRAMIC ACID 3736 STUDY: SUBCHRONIC SPECIES: MICE

WEEK	HIST. NEG. CONT.	NEG. CONTROL	POS. CONTROL	7.5600 MG/KG	25.2000 MG/KG	75.6000 MG/KG	LOG DOSE	ARITH DOSE
1	378/6602 = 0.06	8/ 77 = 0.10	54/ 90 = 0.60**	14/175 = 0.08	10/ 85 = 0.12	20/125 = 0.16	$	$
2	616/8530 = 0.07	10/138 = 0.07	58/ 83 = 0.70**	8/119 = 0.07	5/137 = 0.04	8/ 99 = 0.08		
3	518/8284 = 0.06	7/138 = 0.05	27/154 = 0.18*	18/154 = 0.12	6/147 = 0.04	11/142 = 0.08		
4	544/8077 = 0.07	5/129 = 0.04	26/174 = 0.15	11/174 = 0.06	13/187 = 0.07	12/137 = 0.09		
5	377/7507 = 0.05	5/146 = 0.03	13/199 = 0.07	14/205 = 0.07	15/184 = 0.08	9/159 = 0.06		
6	508/9151 = 0.06	3/ 60 = 0.05	8/199 = 0.04	3/105 = 0.03	5/120 = 0.04	5/106 = 0.05		
7	380/7499 = 0.05	9/170 = 0.05	5/171 = 0.03	6/172 = 0.03	4/139 = 0.03	12/120 = 0.10	$	$

NOTE: THE SYMBOL * DENOTES ANY SIGNIFICANT DIFFERENCE AT THE DOSE LEVELS COMPARED WITH THE NEGATIVE CONTROL.

THE TWO COLUMNS IDENTIFIED AS LOG DOSE AND ARITHMETIC DOSE ARE USED TO NOTE ANY SIGNIFICANT DEVIATION OF THE SLOPE OF THE REGRESSION LINE FROM ZERO.

SIGNIFICANCE IN THE LOG DOSE COLUMN IS CALCULATED USING THE LEVELS OF THE TEST COMPOUND, WHEREAS THE SIGNIFICANCE IN THE ARITHMETIC DOSE COLUMN ALSO INCLUDES THE NEGATIVE CONTROL.

ONE * OR $ INDICATES SIGNIFICANCE AT P LESS THAN 0.05.
TWO * OR $ INDICATES SIGNIFICANCE AT P LESS THAN 0.01.

PROTOCOL

1. PURPOSE

The purpose of this study was to evaluate the test material for its ability to induce dominant lethality in mice.

2. OVERVIEW AND RATIONALE

The dominant lethal assay is designed to determine the ability of a compound to induce genetic damage in the germ cells of treated male mice leading to fetal wastage. Chromosome aberrations including breaks, rearrangements, and deletions are believed to produce the dominant lethality although ploidy changes and chromosome nondisjunction may also be detected in this assay. Male mice are exposed to several dose levels of the test compound for 5 days and then mated over the entire period of spermatogenesis to unexposed virgin females. At mid-pregnancy, the females are killed and scored for the number of living and dead implants as well as the level of fertility. These results are then compared to data from control animals and used to determine the degree of induced dominant lethality.

Evidence of dominant lethality emphasizes that the compound is able to reach the developing germ cells and induce genetic damage. It also suggests, but does not measure directly, that in addition to the detected gross chromosomal lesions, more subtle balanced lesions or specific locus gene mutations may be produced. These latter types have a good chance of being transmitted to the gene pool of future offspring.

3. EXPERIMENTAL DESIGN

Ten (10) random bred, male mice from a closed colony were assigned to 1 of 5 groups. Three of these groups received different dose levels of the test compound; a fourth group received only the solvent or vehicle; and the fifth group received a known mutagen and served as the positive control group. The test compound and control compounds were administered as specified in Table 1. Triethylenemelamine (TEM) was used as the positive control and was given as a single intraperitoneal injection. Following treatment, each male was rested for 2 days and then caged with 2 unexposed virgin females on the third day. At the end of 5 days, these females were removed. This weekly mating sequence was continued for 7 weeks. Each pair of mated females was transferred to a fresh cage, and approximately 14 days after the midweek of being caged with the male, the females were killed with CO_2. At necropsy, their uteri were examined for dead and living implants, and total implantations. Animals which died during dosing were not replaced unless there was 75% mortality at a single dose level. In that case the compound toxicity was reviewed, and the entire dose level was repeated.

3. EXPERIMENTAL DESIGN (Continued)

A. Animals

Random bred, adult male and female mice, strain CD-1 were purchased from the Charles River Breeding Laboratories, Inc. Male and female mice were at least 8 weeks of age when purchased.

B. Animal Husbandry

Males were housed individually and females housed in pairs (except during mating) in shoe box cages on AB-SORB-DRI bedding.

All animals were quarantined prior to being used in the study to acclimate them to the new laboratory conditions. Purina Lab Chow was used as the basic diet food, and water were offered ad libitum. Light was provided on a 12-hour light/dark cycle.

Personnel handling animals or working within the animal facility wore suitable protective laboratory garments, including face masks or respirators.

C. Dosage Determination

Dosage information was calculated on the basis of range finding studies using at least 5 groups of 6 mice each. LD50, LD5, and LD1 concentrations were computer generated based on the preliminary study. The high dose level was selected from these data. One-third and one-tenth of the high dose were used as the intermediate and low dose levels, respectively.

D. Records

The number of dead and living implants, and total implantation sites were recorded on a standardized record form. Data were keypunched directly from these forms to computer entry cards, and analyzed for statistical significance as outlined in Appendix A. Original copies of all data are stored in the Litton Bionetics, Inc. archival system.

4. EVALUATION CRITERIA

Both pre- and post-implantation losses contribute to dominant lethality. The former is reflected in the total number of implantation sites per pregnant female and strictly measured by the difference between the number of corpora lutea gravidus and the number of implantation sites. Toxic or physiological effects on sperm may also reduce the number of implantation sites. Therefore, unless subtle physiological effects on sperm can be discounted, pre-implantation loss is not as rigorous and indication of dominant lethality as post-implantation loss. Corpora lutea cannot be reliably counted in mice and, therefore, pre-implantation loss is not evaluated in studies using mice. Post-implantation losses are measured as early and late fetal deaths plus the number of resorption sites.

Dominant lethality is typically determined from: a) a mutation index derived from the ratio of dead to total implants; or b) the number of dead implants per pregnant female. In interpreting these values it must be remembered that the former measurement reflects both pre- and post-implantation losses and that the ratio is affected by changes in either the numerator or the denominator. For this reason the second parameter is perhaps a better indicator of post-implantation loss. This becomes especially so if one concurrently examines the number of living embryos per pregnant female. The two sets of data should be inversely related. In other words, if true dominant lethality is being observed, then a significant increase in the number of dead implants per pregnant female should be accompanied by a significant decrease in the number of living implants per pregnant female.

These ratios are compared with both concurrent and historical control data for significant statistical differences. Dose-related trends are also looked for, but may not always be found. For example, some compounds such as EMS tested in mice show a threshold value and then a very steep rise. Certain portions of the response might be missed, depending on the spacing of the dose levels used.

True, as opposed to spurious, dominant lethality also tends to cluster according to the stage of spermatogenesis affected and typically would not be expected to appear in widely spaced weeks or blocks of weeks.

All data which are indicated as being statistically significant must also be strongly evaluated for their biological significance. By bringing both statistical and biological selective pressures to bear on the data gathered, an estimate of dominant lethality and of risk to the gene pool should be obtainable.

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APPENDIX A

STATISTICAL ANALYSIS

APPENDIX A

Analysis of Data

1. Fertility Index

a. The fertility index is defined as F.I. = # of pregnant females/ # of mated females. It is calculated for each week (in subacute study) or at the end of 8 weeks (in acute study) and for each dose level, negative control, and positive control.

b. A chi-square test is used to compare each treatment group and positive control to negative control.

$$\chi_i^2 = \frac{(N_0 + N_i)\left(n_0(N_i - n_i) - n_i(N_0 - n_0) - (N_0 + N_i)/2\right)^2}{(n_0 + n_i)(N_0 - n_0 + N_i - n_i)N_0N_i}$$

where

n_i = # impregnated in i-th test group

n_0 = # impregnated in negative control group

N_i = # of females mated in the i-th test group

N_0 = # of females mated in negative control group

A 2 x 2 table is formed as follows:

	control	test
# impreg	n_0	n_i
# not impreg	$N_0 - n_0$	$N_i - n_i$

Significance at the 5 and 1% levels is indicated with asterisks.

c. Armitage's trend for linear proportions is used to test whether the fertility index is linearly related to arithmetic or log dose.

The following table is set up:

	-control	dose 1	dose 2	dose 3	dose k	totals
# impreg	n_0	n_1	n_2	n_3	n_k	t
# not impreg	$N_0 - n_0$	$N_1 - n_1$	$N_2 - n_2$	$N_3 - n_3$	$N_k - n_k$	T - t
totals	N_0	N_1	N_2	N_3	N_k	T

and Armitage's chi-square is calculated:

$$\chi_A^2 = \chi_{(k-1)}^2 - \chi_1^2$$

where

$$\chi_1^2 = \frac{T(\sum_{i=0}^{k} n_i x_i - t\sum_{i=0}^{k} N_i x_i)^2}{t(T-t)(\sum_{i=0}^{k} N_i x_i^2 - (\sum_{i=0}^{k} N_i x_i)^2)}$$

$$\chi_{(k-1)}^2 = \frac{T^2(\sum_{i=0}^{k} n_i^2/N_i - t^2/T)}{t(T-t)}$$

and the x_i are the dose levels. This calculation is repeated with x replaced by $\log_{10} x$. The 5 and 1% significance levels are indicated by dollar signs.

2. Total Number of Implantations

a. The total number of implantations is evaluated by the Student's t-test to determine whether the average number of implantations per pregnant female for each treatment group and the positive control group differs significantly from the negative control group.

n_i = # of pregnant females at dose level i.
u_{ij} = # of implantations for pregnant female j in dose group i.

$$\bar{u}_i = 1/n_i \left(\sum_{j=1}^{n_i} u_{ij}\right)$$

$$S_i^2 = \sum_{j=1}^{n_i} (u_{ij} - \bar{u}_i)^2$$

$$t_i = \bar{u}_0 - \bar{u}_i \Big/ \left(\frac{S_0^2 + S_i^2}{n_0 + n_i - 2} \left(\frac{1}{n_0} + \frac{1}{n_i}\right)\right)^{\frac{1}{2}}$$

$$d.f. = n_0 + n_i - 2$$

Significance at the 5 and 1% levels is indicated by asterisks.

b. A regression fit of the average number of implantations, $\bar{u}_i$, is made for both the arithmetic and logarithmic dose (x_i and log x_i). The doses x_i are used as independent variables and the fit includes data from the three treatment groups and the control group.

N = total # of pregnant females in all groups.

x_i = dose/log (dose) for the i-th female.

U_i = # of implantations for the i-th female.

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$$

$$SS_x = \sum_{i=1}^{N} (x_i - \bar{x})^2$$

$$\bar{U} = \frac{1}{N}\sum_{i=1}^{N} U_i$$

$$SS_u = \sum_{i=1}^{N} (U_i - \bar{U})^2$$

$$S_{xu} = \sum_{i=1}^{N} (x_i - \bar{x})(U_i - \bar{U})$$

B = estimate of slope of regression line = S_{xu}/SS_x

A = estimate of intercept of regression line = $\bar{U} - B\,\bar{x}$

VARU = variance of U about regression line

$$= \frac{SS_u - S_{xu}^2/SS_x}{N-2}$$

VARB = variance of B = $\frac{VARU}{SS_x}$

VARA = variance of A = $\text{VARU}\left(\frac{1}{N} + \frac{\bar{x}^2}{SS_x}\right)$

TB = $B/(\text{VARB})^{\frac{1}{2}}$ = t-statistic for testing the hypothesis that the regression slope is zero.

DF = N-2 = # of degrees of freedom for T B

CVUX = coefficient of variation of U about x

= $(\text{VARU.X})^{\frac{1}{2}}/\bar{U}$

VARU.X = $\frac{1}{N-2}\left(SS_U - S_{XU}^2/SS_X\right)$

SDY = standard deviation of U about the regression line

= $(\text{VARU.X})^{\frac{1}{2}}$

SDS = standard deviation of the slope

= $(\text{VARB})^{\frac{1}{2}}$

SDA = standard deviation of intercept

= $(\text{VARA})^{\frac{1}{2}}$

Significant difference of the slope from zero is indicated at the 5 and 1% levels.

3. Total Number of Corpora Lutea
(For rats only)

a. The average number of corpora lutea per pregnant female is evaluated by t-test to determine whether each treatment group differed significantly from the control group. Use the equation described in Step 2 above with

u_{ij} = # of corpora lutea for pregnant female j in dose group i.

b. A regression fit of the average number of corpora lutea per pregnant female is made for both the arithmetic and logarithmic dose. Use the equations described in Step 2 above with

u_i = # of corpora lutea for the i-th female

4. Preimplantation Losses

(For rats only)

a. The number of preimplantation losses is the number of corpora lutea minus the number of implantations.

Y_{ij} = preimplantation losses for j-th female in i-th group

V_{ij} = # of corpora lutea for j-th female in the i-th group

b. The Freeman-Tukey transformation is applied to the Y_{ij} as follows:

$$f_{ij} = \sin^{-1}\sqrt{\frac{y_{ij}}{V_{ij}+1}} + \sin^{-1}\sqrt{\frac{y_{ij}+1}{V_{ij}+1}}$$

The t-test is then applied to the f's, comparing the test groups to the negative control. Let

$$\bar{f}_i = \frac{1}{n_i}\sum_{j=1}^{n_i} f_{ij}$$

$$s_i^2 = \sum_{j=1}^{n_i} (f_{ij} - \bar{f}_i)^2$$

where n_i = # of pregnant females at dose level i.

Then $t = (\bar{f}_0 - \bar{f}_i)/\left[\frac{s_0^2 + s_i^2}{n_0 + n_i - 2}\left(\frac{1}{n_0} + \frac{1}{n_i}\right)\right]^{\frac{1}{2}}$

c. Regression analysis is used to determine whether the average number of preimplantation losses per female is related to the arithmetic or the log dose. The method is as used in Step 2 above substituting

U_i = # of preimplantation losses for the i-th female.

5. Dead Implantations

The dead implants were evaluated by the same statistical techniques that were used in evaluating the total number of implantations.

Substitute

u_{ij} = # of dead implants for j-th female in the i-th group in the equations in Step 2 above.

6. Proportion of Females with One or More Dead Implantations

The proportion of females with one or more dead implants is the number of females with dead implants/number of pregnant females. These proportions are analyzed by the same method used to analyze the fertility indices, i.e., by a chi-square test and Armitage's trend.

Substitute n_i = # of pregnant females with one or more dead implants at dose level i and

N_i = # of pregnant females at dose level i in Step 1 above.

Also a probit regression analysis is done using these proportions, p_i, to determine whether the probit of p_i is linearly related to the log or arithmetic dose. The Biomedical Computer Program BMD03S is used to compute A and B and the χ^2 statistic for the regression equations $y = A + B\,x$ and $y = A + B \log x$.

7. Proportion of Females with Two or More Dead Implantations

The proportion of females with two or more dead implantations is the number of females with two or more dead implants/number of pregnant females. The data are evaluated by the same method used for evaluating the proportion of females with one or more dead implants.

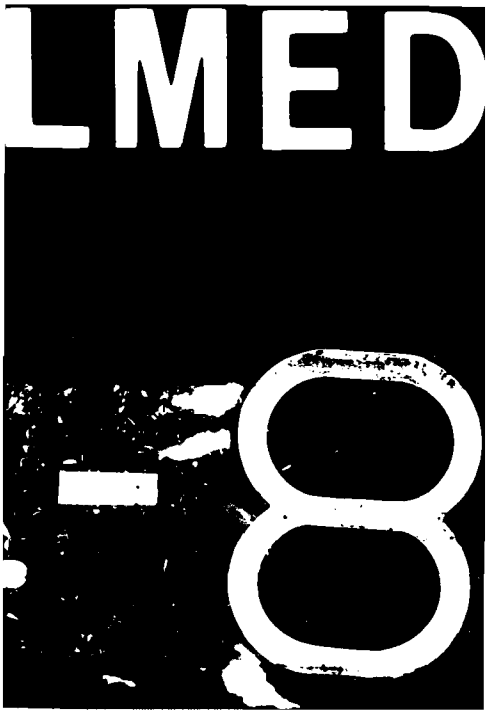
8. Dead Implants/Total Implants

Dead implants/total implants were computed for each female and transformed by way of the Freeman-Tukey arc-sine transformation prior to being evaluated by t-test to compare each treatment group and positive control to negative control.

Use y_{ij} = # dead implants for j-th female in i-th group

v_{ij} = # of total implants for j-th female in i-th group

in the equations in Step 4 above.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